

Method for moving at least two elements of a placement machine as well as such a placement machine

The invention relates to a method for moving at least two elements of a placement machine in and opposite to a predetermined direction, in which the second element is moved by means of the first element.

5 The invention also relates to a placement machine suitable for executing such a method.

In such a method and placement machine known from international patent application WO 97/38567, an arm forming a first element is movable in and opposite to a Y-  
10 direction. To the arm is attached a slide forming a second element, which slide is moved along with the arm when the latter is moved in Y-direction. In the known machine the slide is also movable in a transverse direction extending transversely to the predetermined direction and denoted X.

The slide comprises a component placement element by means of which a  
15 component can be picked up from a pick up plate and subsequently be placed on a desired position onto the substrate. For this purpose the arm, the slide and the component placement element are moved in common in or opposite to the Y-direction and the X-direction. Near to the pick up position and the desired position on the substrate the component pick-up element should be temporarily stopped to enable it to pick up and place the component respectively.  
20 To make the relative fast picking up and placement of components possible, the relatively heavy arm and the component placement element are to be moved as fast as possible between the pick-up position and the desired position on the substrate, which leads to relatively large acceleration and deceleration forces. Since, in addition, the accuracy with which a relatively light component is picked up or moved, respectively, should be relatively high, stringent  
25 requirements are made on the driving and guiding of the arm.

Such a problem is not only found in component placement machines, but in any placement machine with which a relatively small mass is to be moved fast and by means of a relatively large mass.

It is an object of the present invention to provide a method for moving at least two elements in which the second element can be moved relatively accurately and relatively fast to a desired position by means of the first element.

5 This object is achieved in the method according to the invention in that the first element is moved in the predetermined direction while at the same time the second element is moved relative to the first element in a direction opposite to the predetermined direction and vice versa.

10 In this manner it is possible for example to move the first element together with the second element to a desired position in a relatively fast manner. During this operation, near the desired position the second element is moved in opposite direction to the first element. As a result, the second element undergoes a compound move that is determined by the move of the first element in the predetermined direction and the move relative to the second element relative to the first element in the direction opposite to predetermined  
15 direction, or vice versa. The compound move of the second element may be relatively small or even zero, so that the second element is brought to a standstill without the need for the first element to be brought to a standstill as well, so that there will not be any large deceleration forces on the first element.

20 An embodiment of the method according to the invention is characterized in that the first element is moved in the predetermined direction over a distance that is substantially equal to the distance over which the second element is moved in opposite direction.

25 The resulting or compound distance over which the second element is moved will then be substantially equal to zero. This makes it possible for the first element to be moved, whereas the second element remains stopped.

A further embodiment of the method according to the invention is characterized in that the first element is moved in the predetermined direction with a speed that is substantially equal to the speed with which the second element is moved in opposite direction.

30 In this way the resulting speed with which the second element is moved is substantially equal to zero, whereas the speed of the first element need not be adjusted.

A further embodiment of the method according to the invention is characterized in that the second element is also moved in a transverse direction extending transversely to the predetermined direction.

In this way the second element can be moved in a plane extending parallel to the predetermined direction and transverse direction.

Yet a further embodiment of the method according to the invention is characterized in that the second element comprises a component placement element which relative to the second element is moved in a placement direction extending transversely to the predetermined direction.

By means of a component placement element it is possible for a component to be moved accurately and fast to a desired position by means of the placement machine.

Yet a further embodiment of the method according to the invention is characterized in that the second element comprises an imaging device by which images are made.

By means of the imaging device it is possible to make images of a desired position to which the second element is to be moved, which action is preferably carried out while the second element is being moved. This enables the second element to be driven relative to the first element so that the second element is accurately moved close to the desired position.

The invention is also based on a placement machine that avoids the disadvantages of the known machine.

The placement machine according to the invention therefore comprises at least two elements that are movable in and opposite to a predetermined direction, the second element being movable with the aid of the first element, both the first element and the second element further being movable relative to each other in and opposite to a predetermined direction.

In this way it is possible to bring the second element to a standstill while the first element is moved for example at a constant speed, by moving the second element in opposite direction. The second element mass to be brought to a standstill with this action may be relatively small, so that relatively small acceleration forces will occur.

The invention will be further explained with reference to the drawing in which:

Fig. 1 is a plan view of a component placement machine that has a placement machine according to the invention,

Fig. 2 gives a diagrammatic representation of a placement machine according to the invention, in which the second element is located close to the desired placement position,

Fig. 3 shows the placement machine shown in Fig. 2 in which the second  
5 element is located near a pick-up position.

In the Figures like elements carry like reference numerals.

Fig. 1 shows a component placement machine 1 according to the invention,  
10 which comprises an elongated frame 2 over which substrate 3 can be moved in or opposite to a direction indicated by arrow  $P_1$ . The direction indicated by arrow  $P_1$  extends in parallel with the X-direction. The component placement machine 1 further comprises two guide rails 4,5 parallel with each other and extending in Y-direction, transversely to the X-direction. The guide rails 4,5 are located over the frame 2. Between the guide rails 4,5 is an arm 6 which on  
15 either end comprises a guide 7,8 (= first element) by means of which arm 6 is slidably supported on bearings over the guide rails 4,5. The guides 7,8 each comprise a motor by which the guides 7,8 are movable over the guide rails 4 in and opposite to the directions indicated by the arrow  $P_2$  or  $P_3$ , respectively. A guide 9 is movable over the arm 6 by means of a motor in and opposite to the X-direction indicated by the arrow  $P_4$ . The guide 9  
20 comprises at least one component placement machine which in Fig. 1 is hidden from view by the guide 9 and the arm 6. The component placement machine 1 further comprises a number of component feeding devices 10 arranged on both sides of the frame 2 between the guide rails 4,5.

The component placement machine described so far is known per se, for  
25 example, from international patent application WO 97/38567 mentioned in the opening paragraph. For this reason the operation of the component placement machine 1 will be elucidated only concisely. Substrates 3 are moved in steps in the direction indicated by the arrow  $P_1$  over the frame 2, with components being positioned on the substrates 3 in the area between the guide rails 4,5 by means of the component placement element. For this purpose  
30 the guide 9 is moved over the arm 6 while at the same time the guides 7,8 are moved over the guide rails 4,5, so that a desired component can be picked up from the component feeding devices 10 by means of the component placement element. Then the component placement element is taken to a desired position above the substrate 3 via the guides 7,8 after which the

component is positioned in the Z direction at the desired position on the substrate by means of the component placement element.

The mass of the component to be placed is often less than 1 gram. The total mass of the guides 7,8, the arm 6 and the guide 9 is for example 65 to 80 kg. During the move in for example Y-direction this whole mass is constantly to be moved to and fro between the component feeding devices 10 and the desired position on the substrate 3. To be able to place relatively many components per time unit, the arm 6 is to be moved to and fro relatively fast. It should also be possible to quickly bring the arm 6 to a standstill and set in motion again. As a result of the large weight of the arm compared with the weight of the component to be placed, relatively large acceleration and deceleration forces show up during this action. In addition, vibrations occur during this action which are first to be dampened to achieve the desired positioning accuracy, which takes extra time.

Such acceleration forces and deceleration forces as well as vibrations do not occur with a placement machine according to the invention. The placement machine according to the invention will be further explained with reference to Figs. 2 and 3.

In the placement machine 11 diagrammatically shown in these Figures 2 and 3 is included a guide 7 that is movable over a guide rail 4 in and opposite to the Y-direction indicated by the arrow  $P_2$ . For clarity's sake the arm 6 and the guide 9 has been left out in the placement machine 11 and a guide 13 (= second element) supporting a component placement element 12 can be directly moved over a guide rail 14 connected with the guide 7. The guide rail 14 extends in parallel with the guide rail 4. The guide 13 can be moved in and opposite to a Y-direction indicated by arrow  $P_5$ . The direction indicated by arrow  $P_5$  extends in parallel with the direction indicated by arrow  $P_2$ .

In the situation shown in Fig. 2 a component 15 has already been fed from the component feeding device 10 by means of the component placement element 12. Component 15 is to be placed at a desired position on the substrate 3.

For this purpose, the guide 7 together with the connected guide 13 is moved in the direction indicated by arrow  $P_2$  at a relatively high speed. As soon as the component placement element 12 comes in the neighborhood of the desired position on the substrate 3, the guide 13 is moved by means of a regulator in the direction indicated by arrow  $P_5$ , opposite to the direction indicated by arrow  $P_2$ . The placement of the guide 13 in the direction indicated by the arrow  $P_5$  is regulated such that the component 15 is immobile relative to the substrates 3 above the desired position on the substrate 3 and can be placed on the substrate 3. Since only the speed and move of the relatively light guide 13 needs to be

regulated in the neighborhood of the desired position on the substrate 3, the consequent acceleration and deceleration forces will be relatively small, so that the component 15 can be placed on the substrate 3 with relatively high accuracy while the speed at which the total mass of the guide 7 and the guide 13 is moved in the direction indicated by arrow  $P_2$  can be relatively high. Besides, the mass of the guides 7,13 can keep moving steadily, so that no attendant acceleration/deceleration forces and vibrations will develop.

Fig. 3 shows the placement machine 11 represented in Fig. 2 when a component 15 is being picked up from a component feeding device 10. The guide 7 is first moved in a direction opposite to the arrow  $P_2$  from a position above the substrate 3 to a position located above the component feeding device 10. Subsequently, the guide 7 is to be moved again in the direction indicated by the arrow  $P_2$  to the position located above the substrate 3. This reciprocating move of the guide 7 is indicated by the arrow  $P_6$ . To avoid relatively high acceleration and deceleration forces and vibrations, in the neighborhood of the component feeding device 10 the guide 13 is moved in the direction indicated by the arrow  $P_7$  over the guide rail 14, the superposed move of the component placement element 12 being such that the component placement element 12 stands still for a moment at the desired position above the component feeding device 10 to be able to pick up a component 15 from the component feeding device 10. The guide 7 can be slowed down relatively slowly during the pick up and accelerated again to be able to change direction of move so that there are relatively small deceleration and acceleration forces. The relatively light guide 13 can undergo relatively large decelerations and accelerations which results in relatively small deceleration and acceleration forces, as a result of the relatively light weight.

If the placement machine 11 according to the invention is used in the component placement machine 1 shown in Fig. 1, the guide rail 14 can be connected with the guide 9 for example on a side of the arm 6 facing the frame 2. Fig. 1 gives a diagrammatic view of such a guide rail 14 having reference numeral 14'.

The guide 7 can be moved with a speed of 2 meters per second, the time needed for picking up or placing a component being for example 100ms. The length of the guide rail 14 should then be about 200mm to make a sufficient move of the guide 13 possible.

It is also possible to have the relatively light guide 13 both in Y and X-direction in opposite direction to a relatively heavy guide.

It is alternatively possible to provide the guide 9 with a second guide rail 14'' by means of which a second component placement element 12 can be moved. In this fashion

it is possible to pick up two components at the same time or in succession from the component feeding devices 10 and then place them simultaneously or in succession on a substrate 3.

It is alternatively possible to provide the guide 13 not only with a component placement element 12 but also with a camera (16) by means of which a pick-up position on the component feeding device 10 can be observed as well as a desired placement position on the substrate 3 prior to picking up and placing a component 15 respectively. Based on the images perceived by the camera (16), an accurate driving of the guide 13 relative to the guide rail 14 can be realized.

It is also possible for the camera to be installed on a separate slide 13 that can be moved over a separate guide rail 14.

The component placement element 12 for example comprises a pick-up tube that can be moved relative to the guide 13 in and opposite to the Z direction extending transversely to the X and Y-direction.